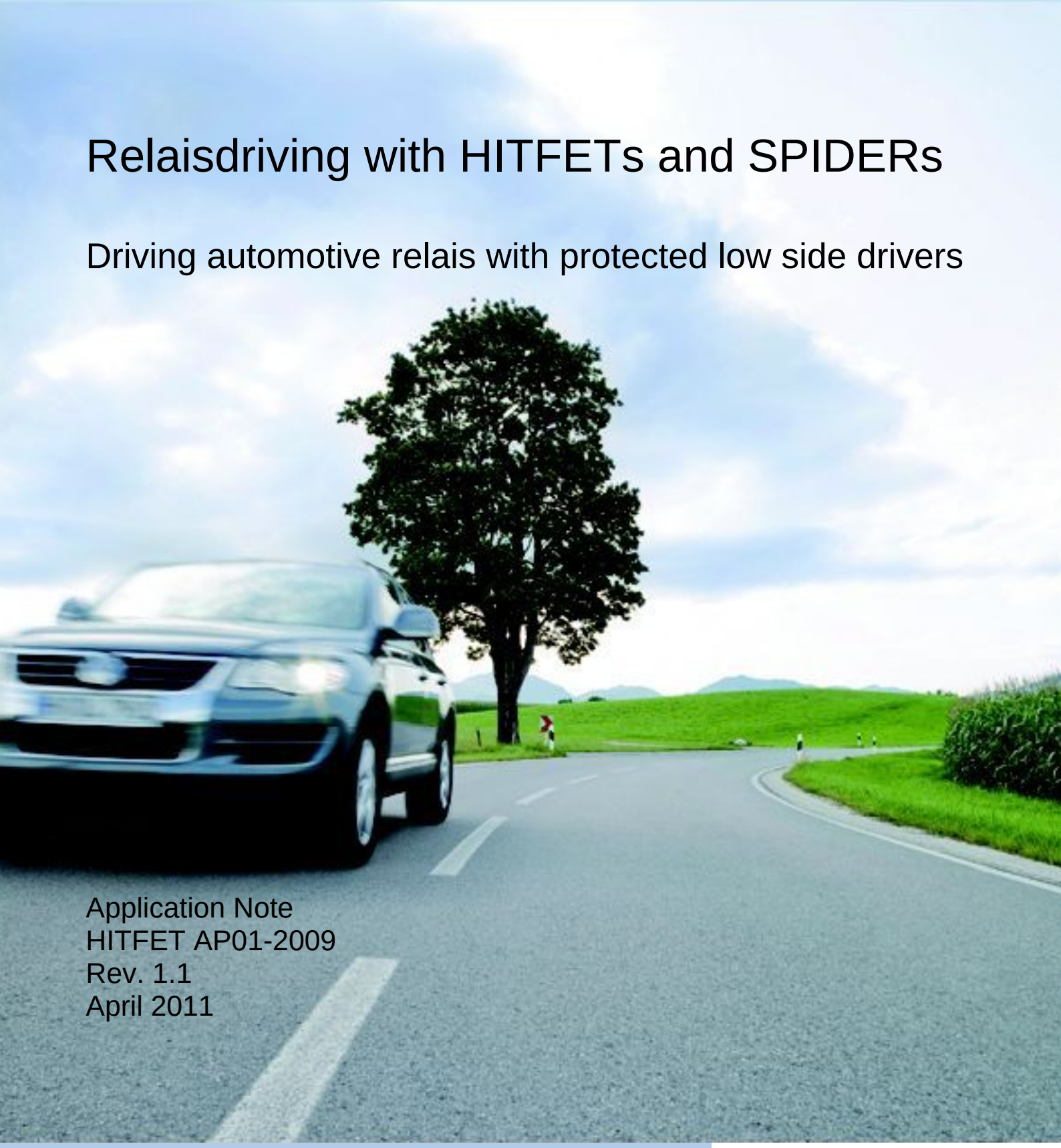
# Relaisdriving with HITFETs and SPIDERs

## Driving automotive relais with protected low side drivers



Application Note
HITFET AP01-2009
Rev. 1.1
April 2011

Automotive Power

Never stop thinking

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# 1 Abstract

This application note should be a short introduction into the automotive relay driving application and give an overview of the Infineon HITFET™ and SPIDER devices which are designed for protected lowside relay driving.
We will continue to improve the content and update the information as necessary.

# 2 Introduction

Even so the Relay is the oldest switch in the electronical portfolio; it is still widely used. Semiconductors strive to replace these “dinosaurs” since more than half a century now. In many areas with remarkable success, however some applications will still use mechanical relays in the next decades to come.
Fault detection and protection are safety features which are widely required today in automotive and industrial applications. A classical mechnical relay has not much to offer in this respect. The protected relay driver needs to protect a shorted coil of the relay from overcurrent and feedback the situation to the microcontroller.

# 3 Relay as load from the driver perspective

Driving a relay is one of the oldest tasks in electronic history. Therefore everybody assumes it is a trivial thing to do. But the surprising part on it is that the load is quite unknown. The switching coil of the Relay is widely neglected in the Datasheets of the Manufacturer. Only a few specify a typical coil resistance, nearly none is mentioning the typical inductance. Not a single one specifies a maximum or minimum value for the coil resistance. Furthermore the variety of relays is adding more uncertainty to the design. There are more than 750 different relais used in automotive applications[1] and a generic driver has to be able to drive them all. Figure1 shows a few automotive relais used today.

**Figure 1 Different automotive Relais in same scale**

In addition to this wide spread of parameters in the relay family, there are dynamic changes of the Inductance. These changes are happening in all relays. During switching, the inductance of a relay changes due to a changing magnetic resistance. When the anchor is lifted, the magnetic flow sees a higher resistance and therefore the inductance changes to a lower value during switch off.
This reflects electrical in a current change during switch ON and a voltage change in switch OFF. Therefore the moment when the load contacts are opening or closing can be seen on the scope.
Figure 2 sketches the current and voltage during switch ON and OFF of a relay.

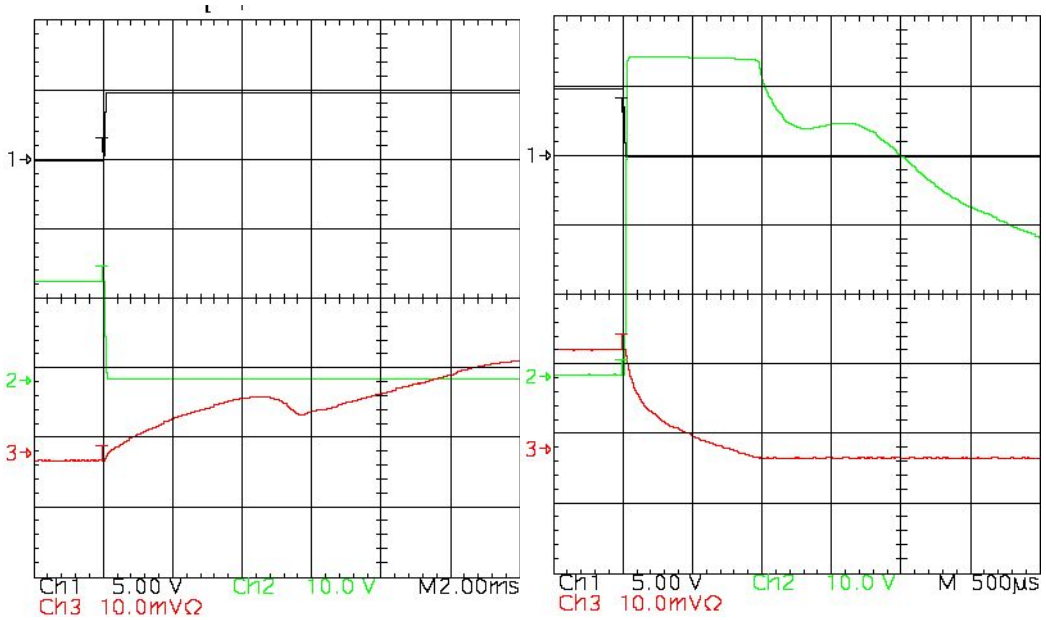


**Figure 2 Current and voltage change during relay switching (Ch3: Drain current, Ch2: Drain voltage and Ch1: IN voltage)**

In the right picture of Figure 2 a voltage rise during switch off above battery level can be seen. This is due to the physical effect that the magnetic energy in the coil raises the voltage on a lowside switch and lowers it on a highside one. The phenomenon is also known as “opening spark”. Some relais have built in parallel resistors to limit this voltage, but most leave it up to the circuit designer to take care on it. Some older Relais had freewheeling diodes included, but this became very unpopular as it reduces the Relaylifetime and causes overload in reverse polarity. Infineon HITFET$^{TM}$ and SPIDER have an internal clamping to limit this voltage.

### 3.1 Electrical description of the automotive relais

In order to get repetive and compareable lab results, there is a schematic defined to replace the unpredictable relay coil.
This circuitry consists out of an inductance and a serial resistor with an optional parallel resistor. The serial resistor represents the copper wire resistance of the coil. Typical resistor values at room temperature are 60 Ohm to 90 Ohm, while the inductance ranges from 400mH to 600mH for a automotive 12V Relay. If a parallel resistor is built in, the value ranges usually from 460 Ohm to 680 Ohm.

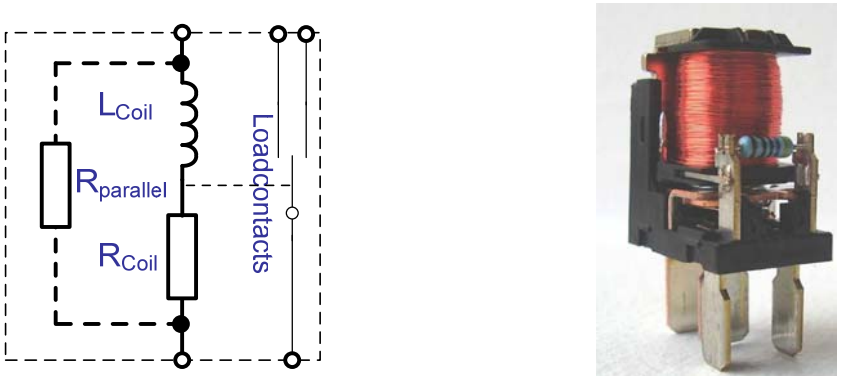


**Figure 3 Electrical schematic vs. Picture of Relay with built in parallel resistor**

### 3.2 Applied circuitry

In the real application there are several different ways of implementing the driver. SPIDER and HITFET™ can handle all of them.

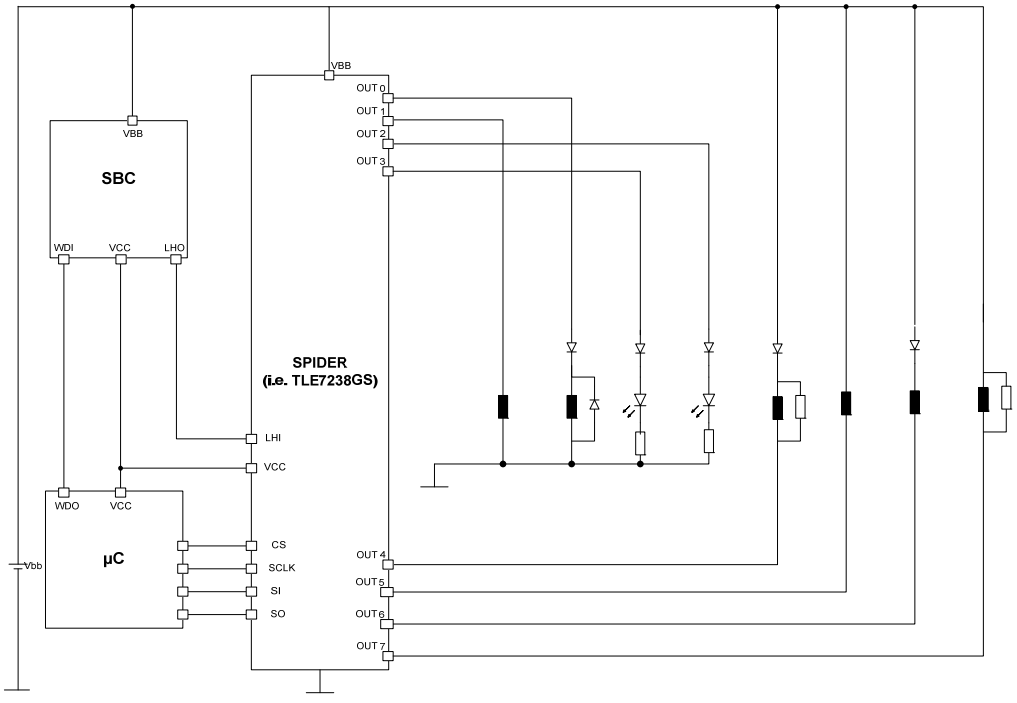


**Figure 4 Relays in different application circuits driven by a HS/LS SPIDER Device**

The Figure 4 shows 6 Relays and 2 signal LEDs in different application setups. There are relais in high- and lowside configuration, with and without parallel resistors, serial diodes and even with the very rare free wheeling diodes.
Serial diodes are not necessary except in case of a freewheeling diode. However sometimes it is not allowed to switch the relay during a reverse polarity event, then the diodes are needed.

## 4 Infineon solution

Infineon offers the SPIDER and HITFET ™ devices with all the functions already integrated into the device. All Devices in the family offer

- ESD protection
- Over load protection
- Short circuit protection and detection
- Internal clamping to overcome the “opening spark” phenomena

All SPIDER offer additionally open load detection and SPI Interfaces, while all HITFET’s offer additionally cranking capability down to 2V.

There are 2 types of protection modes available, latch and restart.
Latching devices are staying off after a protective switch off until the microcontroller resets the device. Despite this a restarting device is switching on again after the device is cooled down below a certain threshold temperature.

Also there are 2 different types of over current protection:
current limitation and threshold.
Limiting devices are limiting the relais current to a specified value and heating up. The over current switch off is then triggered by the temperature sensor.
Threshold devices are switching off as soon as a certain threshold current is reached.
Both protection types are suitable for Relaydriving.
The type of protection needs to be considered when it comes to inrush or capacitive loads.
As threshold protection concepts are triggered from empty capacitors in the load path, while current limiting devices can handle this situation very well.
A threshold protected Device can drive a capacitor anyway, but needs a few restarts from microcontroller.

### 4.1 Portfolio Overview

Infineon's SPIDERs and HITFETs for Relaydriving are summarized in this table.

| Device | Package | Protection type | Qualification Target market | RoHS (Green) | Type Description |
|---|---|---|---|---|---|
| | | | ATV = automotive<br>I = industrial | | |
| **SPIDER** | | | | | |
| TLE7231G<br>TLE7233G | DSO14 &<br>SSOP24 | ESD, Temp, V, I,<br>diagnostic | AEC Q100<br>ATV, I , all | Yes | 4ch low side SPI driver for Relay and LED, latch. Threshold |
| TLE7234G<br>TLE7235G<br>TLE7236G<br>TLE7237SL<br>TLE7238SL<br>TLE7239SL | DSO20 &<br>SSOP24 | ESD, Temp, V, I,<br>diagnostic | AEC Q100<br>ATV, I , all | Yes | 8ch low and high side SPI driver for Relay and LED, latch. threshold |
| TLE7240SL<br>TLE7243SL<br>TLE7244SL | SSOP24 | ESD, Temp, V, I,<br>diagnostic | AEC Q100<br>ATV, I , all | Yes | 8ch low side SPI driver for Relay and LED, latch. threshold |
| | | | | | |
| **HITFET** | | | | | |
| BTS3800SL | SCT595 | ESD, Temp, V, I | AEC Q100<br>ATV, Industrial , all | Yes | Latching, threshold |
| BSP75N | SOT223 | ESD, Temp, V, I,<br>diagnostic | AEC Q100<br>ATV 12V & 24V, all | Yes | Restart, 60V+, Limiting |
| BSP76 | SOT223 | ESD, Temp, V, I,<br>diagnostic | AEC Q100<br>ATV, Industrial , all | Yes | Restart , Limiting |
| BTS3110N | SOT223 | ESD, Temp, V, I,<br>diagnostic | AEC Q100<br>ATV, Industrial , all | Yes | Latch; Limiting |
| BTS3205 | DS08 &<br>SOT223 | ESD, Temp, V, I,<br>diagnostic | AEC Q100<br>ATV, Industrial , all | Yes | Restart, limiting |
| BTS3207N | SOT223 | ESD, Temp, V, I,<br>diagnostic | AEC Q100<br>ATV, Industrial , all | Yes | Restart, limiting |
| BTS3405G | DS08 | ESD, Temp, V, I,<br>diagnostic | AEC Q100<br>ATV, Industrial , all | Yes | Restart, 2ch , Limiting |
| BTS117TC | D2PAK | ESD, Temp, V, I | AEC Q100<br>ATV 12V & 24V, all | Yes | Latch, 60V+, Limiting |
| BTS3408G | DS08 | ESD, Temp, V, I,<br>diagnostic, open load detection | AEC Q100<br>ATV 12V & 24V, all | Yes | Restart, 2ch, 60V+, Limiting |
| BTS3410G | DS08 | ESD, Temp, V, I,<br>diagnostic | AEC Q100<br>ATV, Industrial , all | Yes | Restart, 2ch |

**Table1 Infineon portfolio of protected relay low side switches**

For more information, datasheets, order, contact information please check our homepage out: www.infineon.com/hitfet or www.infineon.com/spider

## 5 Summary

Relaydriving will be still needed in automotive design for the next decade to come. Infineon provides with the HITFET™ and SPIDER products a simple and fast design in solution with high reliability and robustness. These are qualities that are proven in hundreds of millions of HITFETs and SPIDERs, which are used today in a wide range of automotive and industrial electronics. The families just recently released new parts to serve this market best.
The HITFET BTS3205G&N and BTS3405G offer a scalable single / dual channel solution. While the TLE724xSL family features a fully scalable 8ch solution with 4 direct driven channels and limp home capability.

## 6 Demo- or Evaluation Boards available

Infineon provides for all SPIDER products and for many HITFET products evaluation boards. These boards enable a fast start up and in case of SPIDER come along with software to allow a fast usage and customization of the SPI functionality.

## 7 Contact and Ordering Information

For more information, datasheets, order, contact information please check our homepage out: www.infineon.com/hitfet or www.infineon.com/spider

You can also send us an email at:

http://www.infineon.com/cms/en/product/channel.html?channel=ff80808112ab681d0112ab69ddae0347&tab=contacts

Or call us:

International Toll Free: 0(0) 800 951 951 951

Direct Access: +49 89 234 65555

**AP Number: AP01-2009**

**Revision History:**

| Version | Date | Changes |
|---|---|---|
| 1.1 | April 2011 | Added BTS3800SL , updated and reformatted Table,<br>updated Footnote and history |
| 1.0 | August 2009 | Initial version |
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[1] Source: Relaytypes listed in ordering system of a representative European automotive OEM

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